File 5-21701

Joan K. Leavitt, M.D.
Commissioner

OKLAHOMA STATE
DEPARTMENT OF HEALTH

P.O. BOX 53551
1000 N.E. TENTH
OKLAHOMA CITY, OK 73152

AN EQUAL OPPORTUNITY EMPLOYER

March 3, 1989

Cherokee County

CERTIFIED MAIL: Return Receipt Requested

Tahlequah Public Works Authority
Jim Powell, General Manager
P.O. Box 29
Tahlequah, Oklahoma 74464

Re: Plan Number SP3511005
Cherkoee County, Type VIII
Tahlequah Wastewater
Treatment Plant

Dear Sir(s):

Enclosed is an approval of your plan Type VIII to utilize Level II sewage sludge in Cherokee County.

This plan shall be operated and maintained in accordance with the plans and specifications approved by this Department on March 2, 1989, and all standards and rules promulgated pursuant to the Solid Waste Management Act.

This plan is issued subject to the provisions listed on the plan, and upon receipt of this plan, it should be made a part of your permanent records.

We are returning one (1) set of the approved plans and specifications, forwarding one (1) set to the Cherokee County Health Department, and retaining one (1) set for our files.

Very truly yours,

George McBryde

George McBryde, Chief
Water Facilities Engineering Service

GM/DCH/tlj

Enclosures

xc: Cherokee County Health Department
Larry McKee, Chief, General Environmental Services

OKLAHOMA STATE DEPARTMENT OF HEALTH
1000 NORTHEAST TENTH STREET
POST OFFICE BOX 53551
OKLAHOMA CITY, OKLAHOMA 73152

WATER FACILITIES ENGINEERING SERVICE
ENVIRONMENTAL HEALTH SERVICES

SLUDGE MANAGEMENT PLAN APPROVAL

TYPE VIII

Tahlequah Public Works Authority
Tahlequah Wastewater Treatment Plant

PLAN NUMBER: SP3511005

EFFECTIVE DATE: March 2, 1989
EXPIRATION DATE: N/A

having complied with the requirements of the Oklahoma State Department of Health, is hereby granted permission to land apply stabilized sewage sludge (Level II) for agricultural land application.

This plan shall be subject to the following provisions:

1. All operational practices and procedures shall conform to the best public health practice possible.

2. The operation of the site shall be conducted in accordance with the plans and specifications submitted and approved as a part of the permit application.

3. Sludge will be land applied at a maximum application rate of 8 dry ton/acre/year.

4. This approval is for sludge management plan only. Individual sites for land application must be submitted to the Division before sludge application begins. Minimum material to be submitted will be Cation Exchange Capacity, soil pH, PA-N, USGS maps, and land owner agreements.

5. The City of Tahlequah shall immediately notify the county health department in which any spill occurs and shall file a written report detailing how the spill occured and all action within forty-eight (48) hours following the spill.

Gary McBryde _______________ Chief, Water Facilities Engineering Service

Mark Coleman _______________ Deputy Commissioner for Environmental Health Services

Joan K. Leavitt, M.D. _______________ Commissioner of Health

ODH Form No. 852-A
(10-87)

SLUDGE MANAGEMENT PLAN

FOR

AGRICULTURAL BENEFICIAL REUSE

OF

MUNICIPAL SLUDGE

FOR

TAHLEQUAH, OKLAHOMA

TAHLEQUAH PUBLIC WORKS AUTHORITY

HTB, INC.
ARCHITECTS-ENGINEERS-PLANNERS
TULSA, OKLAHOMA
1987

SLUDGE MANAGEMENT PLAN

FOR

AGRICULTURAL BENEFICIAL REUSE

OF

MUNICIPAL SLUDGE

FOR

TAHLEQUAH, OKLAHOMA

STATE OF OKLAHOMA
STATE DEPARTMENT OF HEALTH
APPROVED
George McBryde P.E., Chief
Water Facilities Engineering Service
Joan K. Leavitt, M.D., State Commissioner of Health
By D.C. Hodges Date 3-2-89

TAHLEQUAH PUBLIC WORKS AUTHORITY

HTB, INC.
ARCHITECTS–ENGINEERS–PLANNERS
TULSA, OKLAHOMA
1987

In addition to the influence the influx of students has on the population and subsequent generation of sewage flows, consideration must be given to those persons residing outside the corporate limits, but dependent on the Tahlequah Public Works Authority for water and sewer services. Based upon TPWA records, there are an estimated 5,000 persons outside the city limits that are connected to the water distribution system. Of that number, it is estimated that 20 percent, or 1,000 persons, are also connected to the sewerage collection system.

For the purpose of this report, therefore, the 1985 population tributary to Tahlequah's wastewater treatment facility is assumed to equal 17,700 persons. The 1988 population has been estimated to be 18,860.00.

F. EXISTING WASTEWATER TREATMENT FACILITIES

Tahlequah's present wastewater treatment facility is owned and operated by the Tahlequah Public Works Authority and is located on Tahlequah Creek approximately 0.5 miles north of its confluence with the Illinois River. The facility was designed as a secondary treatment plant for an average daily design flow of 2.0 mgd and a maximum daily design flow of 5.0 mgd. The main structures at the existing treatment plant consist of a headworks pumping station; an aerated grit chamber; a control building; two circular treatment units containing basins for aeration, final clarification, chlorine contract, reaeration and aerobic digestion; and sludge drying beds.

A schematic flow diagram of the existing treatment facility is shown in Figure 2. As can be seen, raw wastewater enters the plant at the headworks where it first passes through a manually cleaned bar screen for removal of large materials then through the comminutor to further reduce incoming solids. The wastewater then flows to the aerated grit chamber where additional solids are removed by gravity settling. Solids settled in the grit chamber are removed by grit pumps and discharged into the grit washer for cleaning and discharge into trash cans for removal. After leaving the grit chamber, the wastewater enters the lift station wet well and is pumped to the treatment units. The treatment units consist of an aeration contact zone where the wastewater is aerated and mixed with activated sludge from the reaeration basin before flowing into the final clarifier for settling. Effluent from the final clarifier flows into the chlorine contact zone before being discharged to Tahlequah Creek.

Sludge handling facilities at the existing facility include an aerobic digester in each of the treatment units, a diffused air system, and sludge drying beds with filtrate and supernatant return systems. The aerobic digesters are operated in the conventional semi-batch mode.

Excess activated sludge is pumped from the reaeration zone to the aerobic digester. Scum from the final clarifier is also air lifted to the digestion unit. The sludge is held in the digester under aeration for approximately 70 days, which has resulted in historical volatile suspended solids reductions between 35 and 50 percent.

As shown on Figure No. 4, approximately 700 lbs of solids are discharged to the drying beds on a daily basis. After reaching a solids concentration of at least 20 percent the sludge is removed from the drying beds and applied to land from a truck mounted dry box spreader. Consequently, the minimum acreage required to satisfy the maximum hydraulic rate criteria of the regulations is 0.5 acres per month (700 lbs/day x 7 day/wk ÷ 0.20 x 8.34 lbs/gal x 25,000 gallons/acres/wk = 0.12 acres per week = 0.5 acres per month) which is approximately one-third of the land required to dispose of the nitrogen quantities. Therefore, the maximum hydraulic rate criteria is not the controlling factor for sludge disposal under the present mode of operation in Tahlequah.

C. FUTURE SLUDGE PRODUCTION

1. **Sludge Quantity.** To meet the future needs of Tahlequah, a 5.27 mgd facility capable of biologically removing nitrogen and phosphorus from wastewater having the following characteristics has been proposed.

BOD_5	115 mgl
SS	115 mgl
NH_3-N	16 mgl
P	4 mgl

As can be seen from Figure No. 5, the theoretical sludge production from the proposed plant, based on the above characteristics, is 3,600 lbs per day. The digested sludge production at the design flow is estimated to be 2,500 lbs per day. At an estimated discharge concentration of 3.47 percent solids, the volume to disposal is approximately 8,630 gpd or 3.15 million gallons per year.

Present plans call for the two existing 84 feet diameter treatment units to be converted to the aerobic digestion units. At the proposed normal sidewater depth of 10 feet, the two converted units will provide 150 percent of the detention time required under aerobic conditions thus enabling the facility to generate level II sludge [2 x 3.14 x (42 feet)^2 x 7.48 gallons/cu. ft. x 10 feet ÷ 8,630 gallons per day = 96 days]. An additional 50 days storage can be obtained during periods of inclement weather by allowing the liquid level to reach a depth of 15 feet. This latter feature will give plant operating personnel the flexibility they need to operate the sludge disposal system during periods of inclement weather.

2. **Chemical Composition.** The chemical composition of the sludge produced by the proposed treatment facility will not be significantly different in terms of heavy metal content than the sludge produced by the existing treatment plant. However, because the proposed facility utilizes a treatment process that converts ammonia nitrogen to nitrates and subsequently converts the nitrates to nitrogen gas, the plant available nitrogen in the sludge will be limited to a small fraction of the influent organic N and that portion of the ammonia nitrogen assimilated into cell mass during the nitrification-denitrification process.

ODEQ-115-0001447

c. On the basis of solids leading criteria, therefore, the governing parameter for the annual application rate for the future facility will be based, on the 8.0 dry tons per acre requirement in the Regulations rather than on the nitrogen content of the sludge.

As noted above, the theoretical quantity of sludge to be disposed of by land application from the proposed facility is 2,500 lbs per day which equals 38 dry tons per month. Therefore, a minimum of 4.75 new acres will be required every month (38 TN/month ·/. 8.0 TN/acre = 4.75 acres/month) to effectively dispose of the solids contained in the sludge.

It was also noted previously that the total volume to be disposed of by the land application system will be 8,630 gallons per day. The minimum acreage required to satisfy the maximum hydraulic rate criteria of the regulations, therefore, is 2.41 acres/wk (8,630 gpd x 7 days/wk ·/. 25,000 gal/acre/wk = 2.41 acres/wk) or 10 new acres per month. Because the hydraulic application criteria requires twice the acreage required of the solids disposal criteria it will become the controlling factor for sludge disposal during the operation of the future facility.

4. Aerobic Sludge Digestion Testing and Records. The aerobic digestion process is a continuation of the aeration process performed in the activated sludge nitrification basins. The bacterial action begun in the aeration process continues in the presence of oxygen but the organic food available is limited. The result is the self-destruction of active bacteria, producing a stable, odorless sludge.

To determine the efficiency of the digestion process, total suspended solids and volatile suspended solids tests should be performed. The reduction in volatile suspended solids should be apparent from the comparison of the ratio of total suspended solids to volatile suspended solids before and after digestion.

An operating log will be maintained by the plant's operating personnel to provide useful information that will aid in the operation of the aerobic digestion process. The log should include as a minimum the following:

Method of Operation
- Single-Stage
- Two-Stage

Dissolved Oxygen
- Basin No. 1
- Basin No. 2

Decanting
- Frequency
- Depth

Additional information should be obtained and recorded to determine the efficiency and cost of operating the digesters. This information includes the total and volatile suspended solids in the waste sludge, the daily ambient and basin temperatures, and the volume and concentration of digested sludge pumped to land disposal. A sample operations report form for the aerobic sludge digestion process is included in Appendix D.

D. ANNUAL LAND REQUIREMENTS

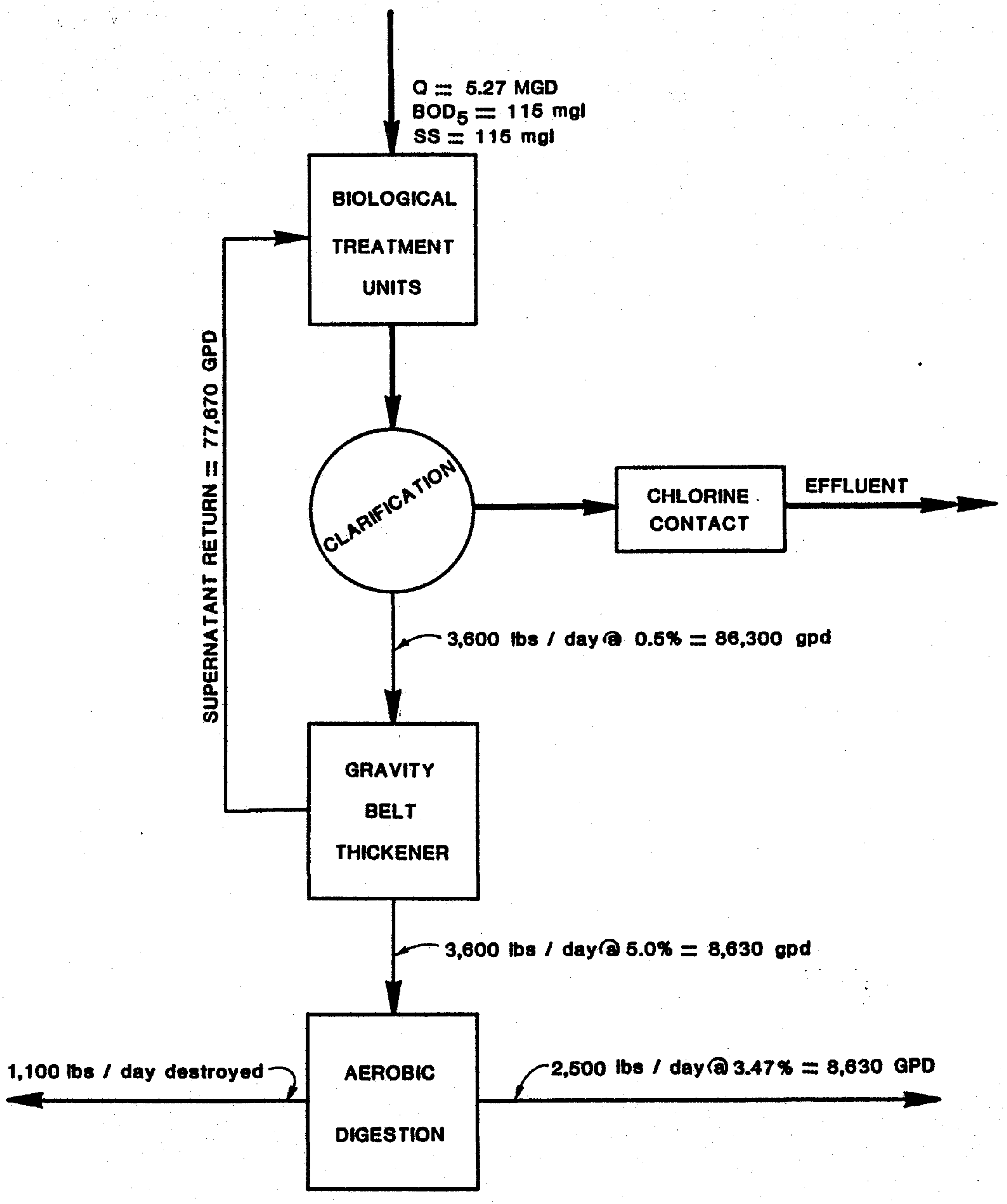
From the preceding analysis the minimum annual acreages required for land disposal of sludge in Tahlequah can be calculated to equal 17 acres for the existing treatment plant and 120 acres for the future facility. In practice, however, between two and four times the required minimum acreages must be secured for a sludge disposal program to be successful.

It is, therefore, recommended that the Tahlequah Public Works Authority initially secure between 60 and 80 acres on which to dispose of the sludge generated by the existing treatment plant. By the time the proposed wastewater treatment facility is constructed and the method of sludge disposal is converted from the present cake disposal operation to a liquid sludge disposal operation, sufficient additional acreage should be secured to accommodate the increased sludge production.

E. INTERIM OPERATION DURING CONSTRUCTION

As previously noted, digested sludge from the existing facility is wasted to the drying beds where it reaches a level II state before being removed and disposed of by application to land from a truck mounted dry box spreader. Following construction of the new treatment facility and subsequent change in the sludge stabilization scheme the sludge drying beds will no longer be required. In an effort to minimize the impact of the new facility on the floodplain of Tahlequah Creek, it may be necessary to construct the new biological basin complex in the area occupied by one-half of the drying beds. Because the loss of drying beds will impact the present method for obtaining a disposable sludge, some provision would have to be implemented during construction to satisfy the regulatory requirements related to the production of level II sludge.

Should a portion of the drying beds be removed from service to accommodate the new treatment facilities, the most likely scenario for obtaining level II sludge during construction will involve the installation of the proposed gravity belt thickener early in the construction process and operating the existing aerobic digestion system at a solids concentration high enough to assure level II sludge generation. Assuming that solids removed from the reaeration zone can be concentrated from 0.7 to 5 percent on the belt thickener it can be shown that the volume of sludge to the existing aerobic digesters can be reduced from 15,570 to 2,180 gallons per day (909 lbs. per day/0.05 x 8.34 lbs. per gallon = 2,180 gallons per day).



HTB, INC.
ARCHITECTS
ENGINEERS
PLANNERS

TAHLEQUAH PUBLIC WORKS AUTHO

SLUDGE MANAGEMENT PLAN

SLUDGE PRODUCTION
FUTURE CONDITIONS

FIGURE NO.

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I. EXECUTIVE SUMMARY

This document describes the development of a sludge management plan that provides for an effective and environmentally sound means of managing the residual solids generated at the wastewater treatment facility in Tahlequah, Oklahoma. The selected management plan involves the application for stabilized sludge to agricultural land at agronomic rates for use as a source of fertilizer nutrients.

The plan has been developed in accordance with the Oklahoma State Health Department Regulations for Solid Waste Management and for Sludge Management and is intended to accommodate disposal of aerobically digested sludge from both the present contact stabilization plant and the proposed biological phosphorus removal facility. As indicated in Section II all of the sludge produced at the wastewater treatment facility in Tahlequah is generated from domestic wastes. The three sources of domestic wastewater in Tahlequah are the residential areas, commercial districts, and institutional facilities.

Section II also contains a discussion of sludge handling facilities at both the existing and proposed facilities. Sludge handling facilities at the existing treatment plant include aerobic digestion and sludge drying beds. The aerobic digesters are operated in a conventional semi-batch mode. Excess activated sludge is pumped from the reaeration zone to the aerobic digester where it is held under aeration for approximately 70 days. This method of operation has resulted in historical volatile suspended solids reductions between 35 and 50 percent.

Digested sludge is wasted to one of twenty-four drying beds. Each bed has a surface area of 2,310 square feet and consists of graded crushed rock topped with a 9-inch layer of sand. The stabilized dried sludge is removed from the drying beds and disposed of by application to land from a truck mounted dry box spreader.

In the development of the "Facilities Planning Report for Tahlequah, Oklahoma", three sludge handling alternatives were initially investigated for the ultimate disposal of solids from the future treatment facility. Based on the evaluation presented in that report, it was concluded that the liquid sludge handling alternative is the most cost-effective option for sludge disposal in Tahlequah.

The proposed sludge treatment scheme for the future facility, therefore, includes thickening and stabilization prior to ultimate disposal. Thickening will be accomplished using a gravity belt dewatering device and stabilization will be achieved through aerobic digestion of the sludge.

Section III of the report summarizes the sludge disposal planning considerations and includes a discussion on the present and future sludge production and quality, the present and future sludge application rates, and the site selection criteria for preliminary screening criteria of application sites. Based on the information presented in this section, the minimum annual acreages required for land disposal of sludge in Tahlequah can be calculated to equal 17 acres for the existing treatment plant and 100 acres for the future facility. In practice, however, it has been demonstrated that anywhere between two and four times the required minimum acreages must be secured for a sludge disposal program to be successful.

It is therefore recommended that the Tahlequah Public Works Authority initially secure between 60 and 80 acres on which to dispose of the sludge produced by the existing treatment plant. By the time the proposed wastewater treatment facility is constructed and the method of sludge disposal is converted from the present cake disposal operation to a liquid sludge disposal operation, sufficient additional acreage should be secured to accommodate the increased sludge production.

Section IV presents information on which the technical evaluation of potential sludge land application sites can be made. Section V outlines a site procurement procedure that, when followed, will culminate in the acquisition of suitable sludge disposal sites. Section VI presents a discussion of several operation and management techniques that are useful in minimizing the adverse impacts of a sludge application system and can aid in maintaining public acceptance of the program.

II. INTRODUCTION

A. PURPOSE

In May, 1984, the Tahlequah Public Works Authority retained HTB, Inc. to provide certain consulting engineering services related to the development of a sludge management plan for agricultural beneficial reuse of municipal sludge for the City of Tahlequah, Oklahoma. Subsequent to that agreement, the Authority decided to expand the present wastewater treatment facility and to do so under the EPA Construction Grants Program. That decision necessitated delay in the final completion of the sludge management plan so that the plan ultimately approved by the Oklahoma State Department of Health would be applicable to both the existing and future wastewater treatment facilities.

It is the purpose of this report to present a sludge disposal plan that provides an effective means of managing the residual solids generated at Tahlequah's wastewater treatment facility in an environmentally sound manner. The plan presented herein has been developed in accordance with Chapter 6 - "Beneficial Use of Treatment Plant Sludges By Land Application" contained in the OSDH Regulations For Solid Waste Management and For Sludge Management. A copy of Chapter 6 is included in Appendix A.

B. SCOPE

The development of this sludge management plan for agricultural beneficial reuse of municipal sludge included the following tasks:

1. Identification and review of Federal, state, and local sludge disposal requirements that affect the ultimate disposal of sludge from both the existing and proposed wastewater treatment facilities in Tahlequah.

2. Evaluation of planning considerations including population, sludge quantity, land use, and sludge quality requirements.

3. Identification of potential sludge disposal sites, using existing soil map information and considering topographical and geological conditions, flood plain areas, and potential transportation routes.

4. Acquisition of more detailed information on potential disposal sites and development of an Agricultural Beneficial Reuse Site Plan for each suitable disposal location.

C. REGULATIONS AND GUIDELINES

The Oklahoma State Department of Health has issued regulations, which apply to the disposal of sludge from wastewater treatment plants. Under these regulations, no solid waste, including treatment plant sludge, can be disposed of at a site or facility which does not have a permit issued by OSDH. Sludge is defined under the regulations as a "special waste" unless it is found to be hazardous by EPA's definition, in which case it is defined as a "controlled industrial waste".

Solid waste disposal facilities are classified on the basis of processing methods used at the facility, and/or on the volumes and types of wastes processed or disposed of at the facility. A site or facility for beneficial use of wastewater treatment plant sludges by land application at agronomic rates is a Type VIII site.

The State Health Department has also issued informational guidelines for sludge management and site plans. Their purpose is to aid city governments and authorities, engineers, farmers, and other interested persons in arriving at the most cost-effective, environmentally sound alternative that offers protection to public health and welfare, provides for ground and surface water pollution control, and avoids odor and nuisance conditions.

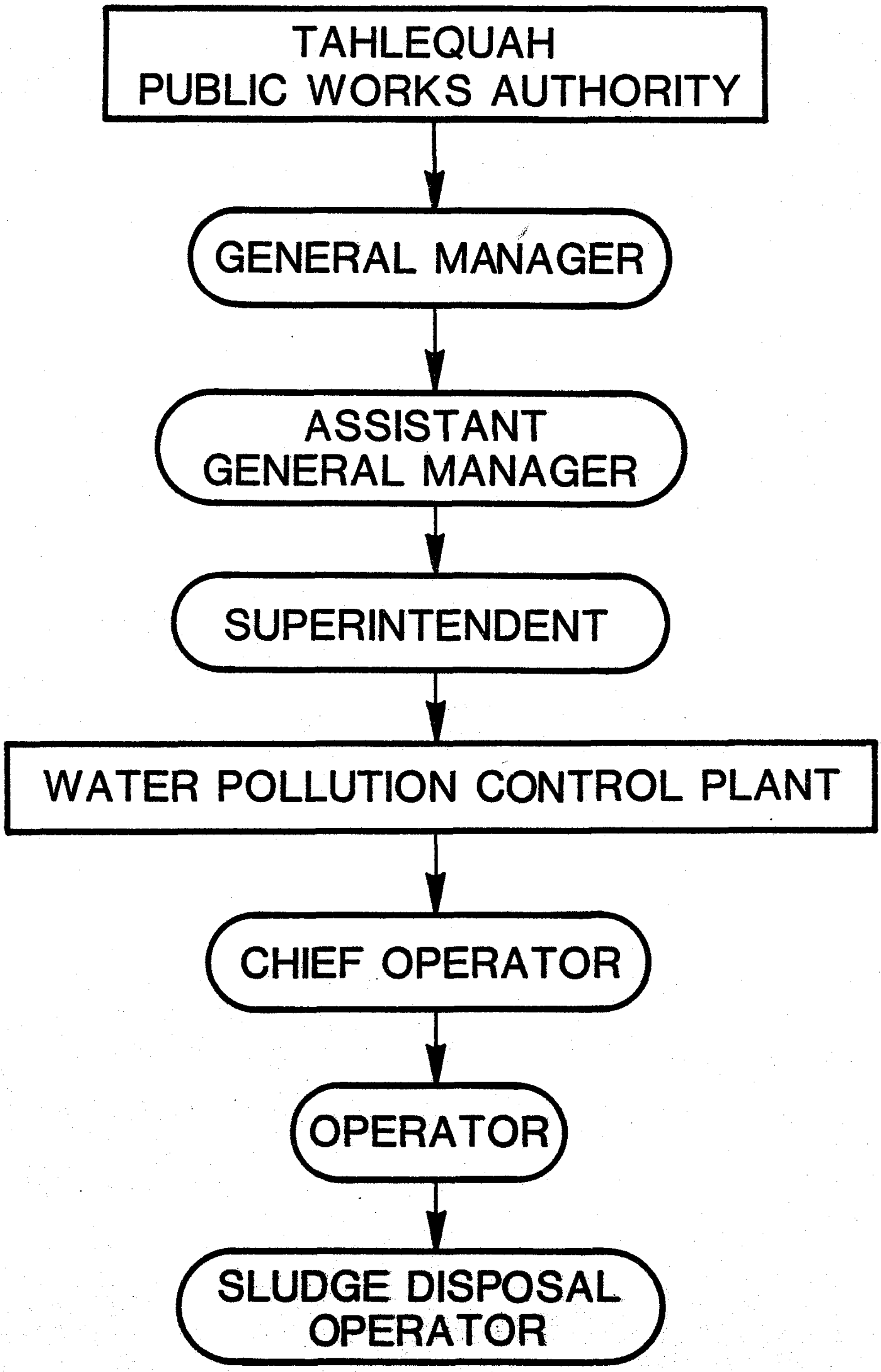
D. PLANNING PARTICIPATION AND COORDINATION

As the applicant, the Tahlequah Public Works Authority has had the overall responsibility for the development of this Sludge Management Plan. The organizational chart of persons responsible for the implementation and operation of this Sludge Management Plan is shown on Figure 1.

E. SLUDGE SOURCES

Because there are no industrial concerns located in Tahlequah, all of the sludge produced by the wastewater treatment facility is generated from domestic wastes. The three sources of domestic wastewater in Tahlequah are the residential areas, commercial districts,and institutional facilities.

According to the Economic Analysis Unit of the Oklahoma Security Commission, the official 1985 population of Tahlequah was 12,500 persons. That figure, however, does not reflect the student enrollment at Northeastern Oklahoma State University, which for the 1986-87 academic year includes 8,400 students. Of this number, approximately 2,000 students live full time in Tahlequah and another 2,200 students commute from the surrounding area. The remaining 4,200 students, however, must be added to the above figures to obtain a more realistic picture of Tahlequah's population.



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SLUDGE MANAGEMENT PLAN

ORGANIZATIONAL CHART

FIGURE NO. 1

In addition to the influence the influx of students has on the population and subsequent generation of sewage flows, consideration must be given to those persons residing outside the corporate limits, but dependent on the Tahlequah Public Works Authority for water and sewer services. Based upon TPWA records, there are an estimated 5,000 persons outside the city limits that are connected to the water distribution system. Of that number, it is estimated that 20 percent, or 1,000 persons, are also connected to the sewerage collection system.

For the purpose of this report, therefore, the present day population tributary to Tahlequah's wastewater treatment facility is assumed to equal 17,700 persons.

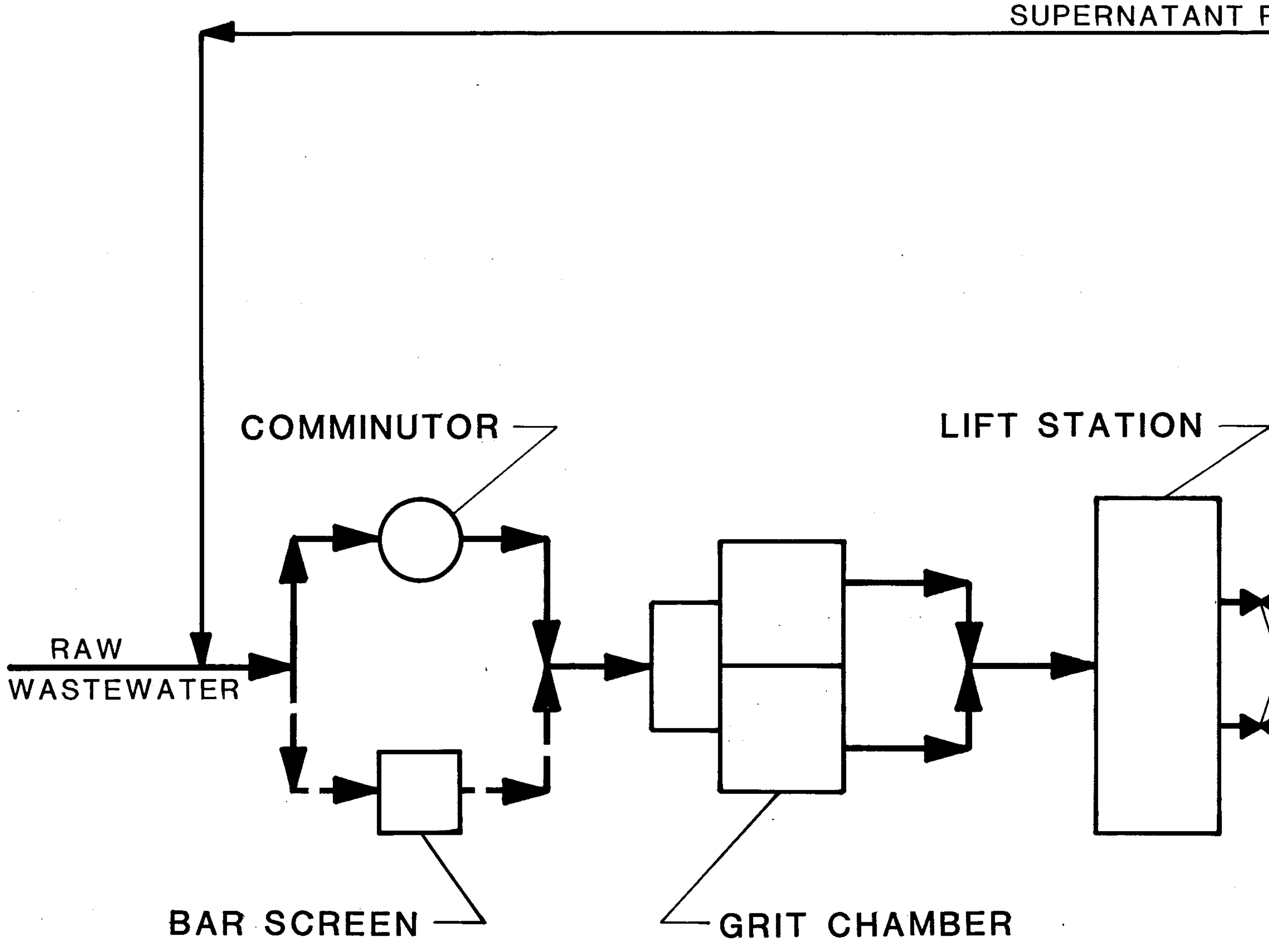
F. EXISTING WASTEWATER TREATMENT FACILITIES

Tahlequah's present wastewater treatment facility is owned and operated by the Tahlequah Public Works Authority and is located on Tahlequah Creek approximately 0.5 miles north of its confluence with the Illinois River. The facility was designed as a secondary treatment plant for an average daily design flow of 2.0 mgd and a maximum daily design flow of 5.0 mgd. The main structures at the existing treatment plant consist of a headworks pumping station; an aerated grit chamber; a control building; two circular treatment units containing basins for aeration, final clarification, chlorine contract, reaeration and aerobic digestion; and sludge drying beds.

A schematic flow diagram of the existing treatment facility is shown in Figure 2. As can be seen, raw wastewater enters the plant at the headworks where it first passes through a manually cleaned bar screen for removal of large materials then through the comminutor to further reduce incoming solids. The wastewater then flows to the aerated grit chamber where additional solids are removed by gravity settling. Solids settled in the grit chamber are removed by grit pumps and discharged into the grit washer for cleaning and discharge into trash cans for removal. After leaving the grit chamber, the wastewater enters the lift station wet well and is pumped to the treatment units. The treatment units consist of an aeration contact zone where the wastewater is aerated and mixed with activated sludge from the reaeration basin before flowing into the final clarifier for settling. Effluent from the final clarifier flows into the chlorine contact zone before being discharged to Tahlequah Creek.

Sludge handling facilities at the existing facility include an aerobic digester in each of the treatment units, a diffused air system, and sludge drying beds with filtrate and supernatant return systems. The aerobic digesters are operated in the conventional semi-batch mode.

Excess activated sludge is pumped from the reaeration zone to the aerobic digester. Scum from the final clarifier is also air lifted to the digestion unit. The sludge is held in the digester under aeration for approximately 70 days, which has resulted in historical volatile suspended solids reductions between 35 and 50 percent.



TREATMENT UNIT LEGEND

SR	SLUDGE RECYCLE
SW	WASTE SLUDGE
SN	DIGESTER SUPERNATANT
M	MAIN PLANT FLOW

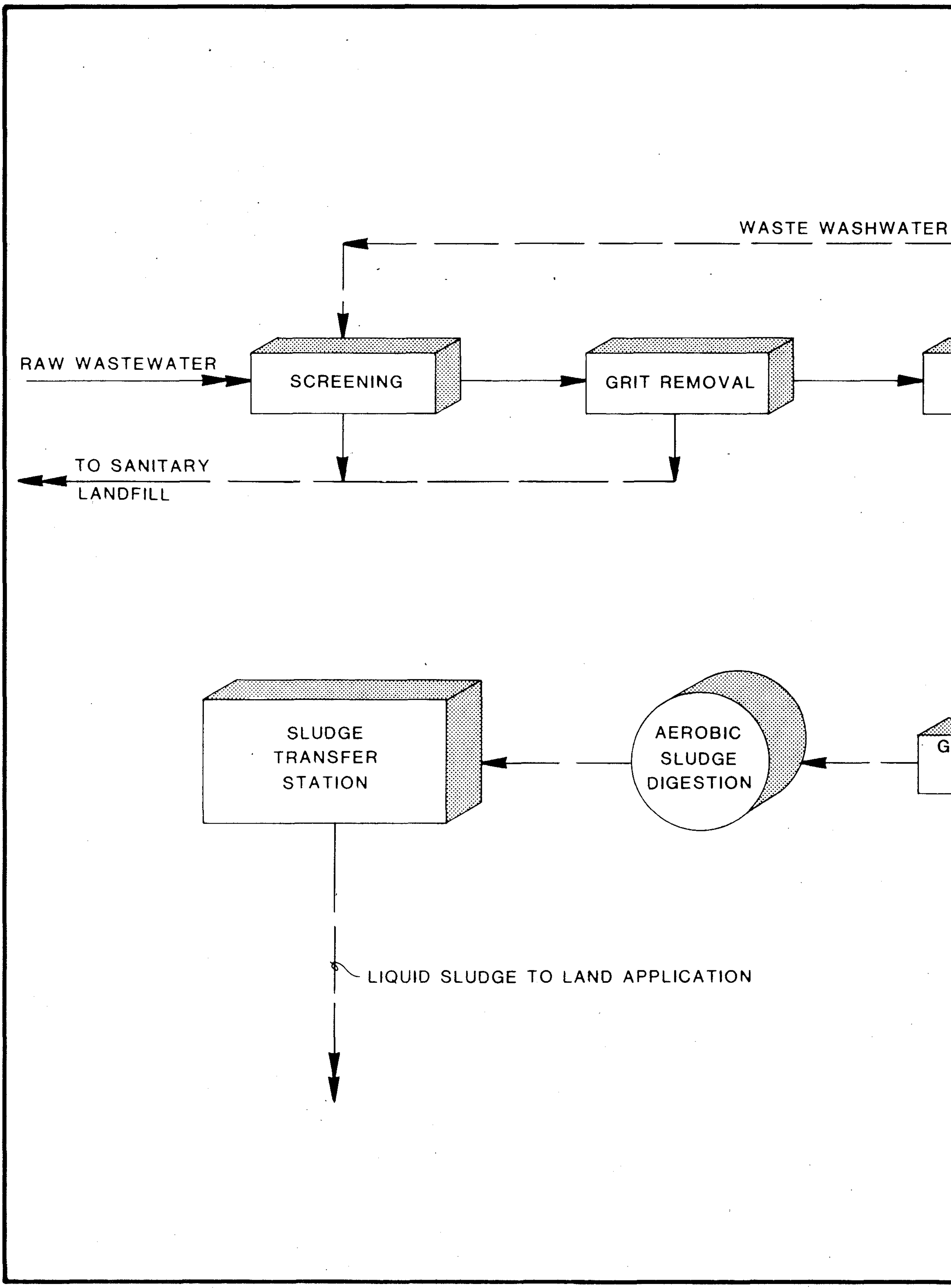
Digested sludge is wasted to one of twenty-four drying beds. Each bed has a surface area of 2,310 square feet and consists of graded crushed rock topped with a 9-inch layer of sand. The stabilized dried sludge is removed from the drying beds and disposed of by application to land from a truck mounted dry box spreader.

G. FUTURE WASTEWATER TREATMENT FACILITIES

The existing treatment facility has consistently provided BOD and suspended solids removal efficiencies within the 90-95 percent range. Although these levels of removal efficiencies are quite good for most conventional treatment processes, the present facility cannot meet the proposed effluent limitations for phosphorus and nitrogen. As a result, the construction of a biological phosphorus removal system utilizing sequential batch reactors has been proposed for Tahlequah. A schematic of the future treatment facility is shown in Figure 3.

Sequential batch reactors, or SBR's as they are commonly known, operate as fill and draw activated sludge systems. A single tank provides for activated sludge aeration, settling, effluent withdrawal, and sludge recycle. The operation steps consist first of a fill period where flow is diverted to one of the SBR tanks while the other tank(s) operates in the reaction, settle, effluent withdrawal, or idle operation sequences. After the fill period, the reactor contents are mixed but not aerated to provide the anaerobic fermentation period for phosphorus release and update of soluble fermentation products. The next step is the reactor aeration period followed by a selected settling time during which both aeration and mixing are stopped. The effluent is then withdrawn and sludge is wasted as needed to control MLSS concentration. Mixed liquor remains in the basin for the treatment in the next cycle.

As can be seen in Figure 3, the proposed sludge treatment scheme for the future facility includes thickening and stabilization prior to ultimate disposal. Thickening will be accomplished using a gravity belt dewatering device and stabilization will be achieved through aerobic digestion of the sludge. Supernatant from the gravity belt will be returned to the biological treatment process.


WASTE WASHWATER
RAW WASTEWATER
SCREENING
GRIT REMOVAL
TO SANITARY
LANDFILL
SLUDGE
TRANSFER
STATION
AEROBIC
SLUDGE
DIGESTION
G
LIQUID SLUDGE TO LAND APPLICATION

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III. SLUDGE DISPOSAL PLANNING CONSIDERATIONS

A. GENERAL

The design of wastewater treatment facilities has historically placed emphasis on the removal of pollutants from wastewater to prevent degradation of receiving waters. Little emphasis, however, has been placed upon the proper disposal of solid residues (sludges) generated at these facilities. Improper disposal of wastewater sludges can adversely affect surface and groundwater, soil, vegetation, public health, and the general public welfare.

Regulations promulgated pursuant to the Oklahoma Solid Waste Management Act allow the application of wastewater treatment plant sludges to land at agronomic rates beneficial as a soil enrichment. However, the governing regulations stipulate that only Level II (sludge that has been conditioned by a process that significantly reduces pathogens) or Level III (sludges that have been conditioned by a process that further reduces pathogens) may be applied to land.

Level II sludge can be obtained by aerobic digestion, air drying, lime stabilization, anaerobic digestion, or composting. Aerobically digested level II sludge can be achieved by agitating the solids with air or oxygen to maintain aerobic conditions, at residence times ranging from sixty days at 15° C to forty days at 20° C, with a volatile solids reduction of at least 38 percent. Air drying of sludge requires that liquid sludge be allowed to drain and/or dry on underdrained sand beds or on paved or unpaved basins where the sludge is at a depth of nine inches. A minimum of three months is needed, two months of which the daily temperatures must average above 0 degrees C.

Lime stabilization of sludge involves the mixing of hydrated lime with water to form a lime slurry, then mixed with the sludge to maintain a minimum pH of 12 for a two hour contact period. Anaerobic digestion of sludge involves the decomposition of organic and/or inorganic matter in the absence of air, at residence times ranging from sixty days at 20° C to fifteen days at 35° to 55° C, with a volatile solids reduction of at least 38 percent. Level II sludge can be obtained using one of several acceptable composting methods provided the solids are maintained at minimum operating conditions of 40° C for five days and provided the temperature exceed 55° C for four hours during the five day period.

B. PRESENT SLUDGE PRODUCTION

1. <u>Sludge Quantity.</u> A review of the monthly operational reports for 1986 indicated that the average daily flow recorded at the present treatment facility was 3.4 mgd. The review also revealed that the average influent BOD and suspended solids concentrations were 90 and 80 mgl, respectively. On average, therefore, the theoretical quantity of activated sludge solids wasted from the final clarifiers on a daily basis can be calculated to equal 1,220 pounds.

Under normal operating conditions, the mixed liquor suspended solids concentrations in the contact, reaeration and digestion zones are maintained at approximately 3,000, 7,000 and 12,000 mgl, respectively. On average, therefore, approximately 15,600 gallons are discharged to the aerobic digesters on a daily basis (See Figure No. 4). From the aerobic digester units an average of 6,300 gallons or 840 cubic feet of sludge are discharged to the drying beds on a daily basis. Under normal circumstances, the sludge is applied to the drying beds at a depth of 10 to 24 inches. Consequently, the area of drying bed occupied by each day's sludge production is between 420 and 560 square feet.

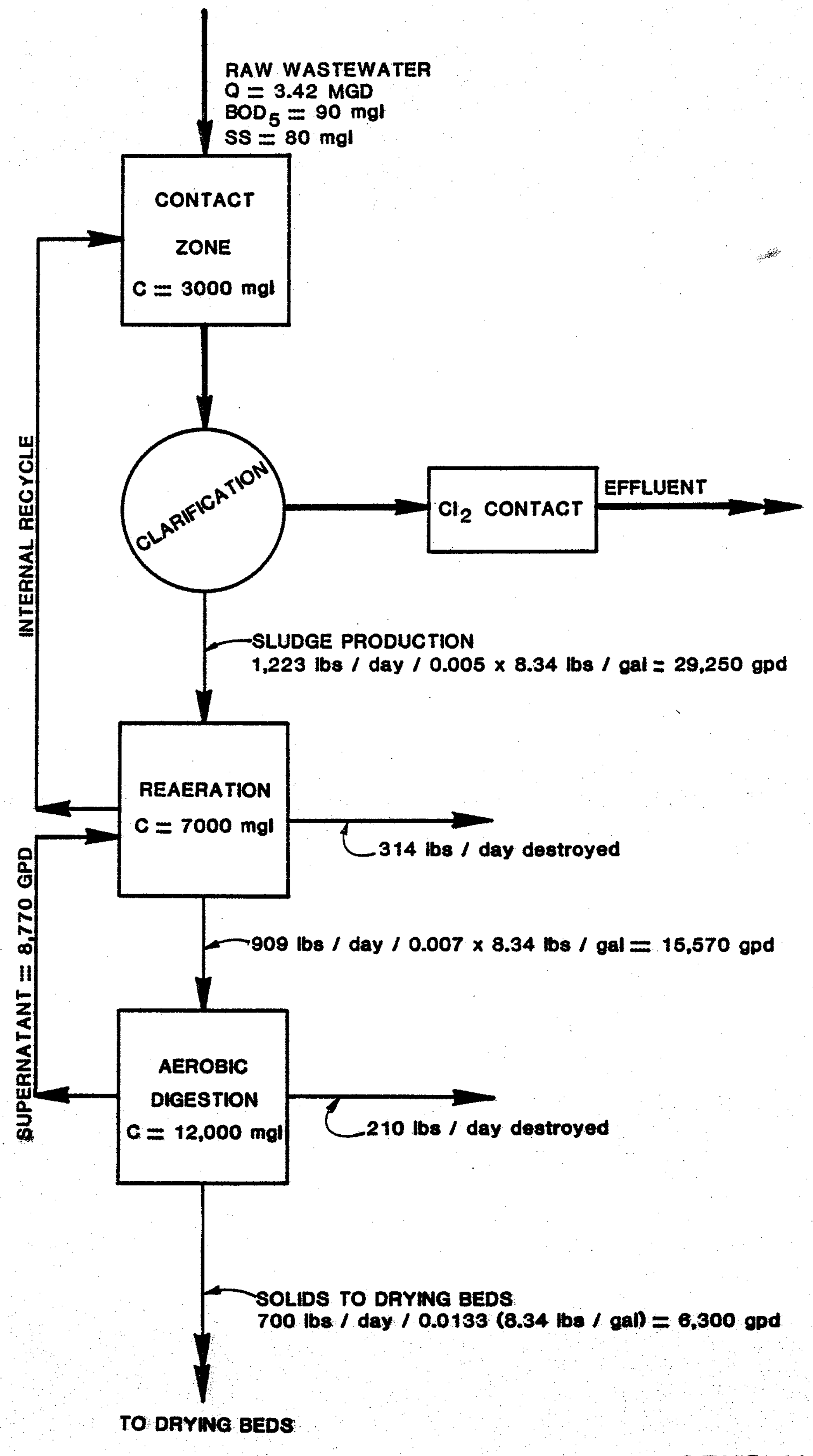
As previously stated, the existing treatment facility has twenty-four drying beds with a total surface area of 55,440 square feet. It can be shown, therefore, that the drying time on the sludge beds ranges from between 99 and 132 days and that a level II sludge can be obtained.

2. **Chemical Analysis.** Samples of the sludge produced at the existing wastewater treatment facility were taken on July 24, 1984, and analyzed by Environmental Consultants Laboratory. The complete results of the chemical analysis can be found in Appendix B. However, the results obtained for the more critical elements are as follows:

TKN	44,533.0	Lead	479.3
NO_3-N	4,523.0	Copper	724.2
NH_3-N	3,897.0	Zinc	1,650.0
Phosphorus	7,753.0	Nickel	29.6
Potassium	3,814.0	Cadmium	7.8
PCB's	0.63	Selenium	0.1

3. **Determination of Application Rates.** According to Chapter 6 of the OSDH Regulations, the annual application rate shall not exceed 8 dry tons per acre or the annual available nitrogen and phosphorus consumptive use of the crop to be produced and shall not be applied at rates that result in phytotoxicity. Additionally, the maximum annual Cadmium application shall not exceed 0.446 lbs per acre and the weekly hydraulic loading shall not exceed 25,000 gallons per acre.

Although the Regulations state that plant food needs must not be exceeded, information obtained from the Cooperative Extension Service of Oklahoma State University suggests there should not be a concern over phosphorus concentrations. Since much of the phosphorus in sludge is in the organic fraction and since the zinc concentration is sufficient to prohibit a phosphorus induced zinc deficiency, the Cooperative Extension Service has concluded that land application of sludge will cause no harmful effects or plant growth. (See letter dated October 7, 1987, from Dr. Billy B. Tucker to HTB, Inc. in Appendix C).



TAHLEQUAH PUBLIC WORKS AUTHORITY

SLUDGE MANAGEMENT PLAN

HTB, INC.
ARCHITECTS
ENGINEERS
PLANNERS

EXISTING SLUDGE PRODUCTION

FIGURE NO. 4

With the aforementioned facts in mind, the annual application rate for present day sludge production can be determined as follows:

a. Assume sludge is applied to a Bermuda grass pasture which has a nitrogen requirement of approximately 250 lbs per acre PA-N.

b. Calculate PA-N value from the results of the sludge analysis of sludge to be applied as follows:

   TKN - Inorganic N = Organic N
   Determine 20% of Organic N
   Add inorganic N to 20% of organic N
   44,533 ppm - 8,420 ppm = 36,113 ppm
   36,113 ppm x 0.20 = 7,223 ppm
   8,420 ppm + 7,223 ppm = 15,643 ppm PA-N

c. Determine pounds of PA-N per dry ton of sludge and divide into pounds of Nitrogen required for the crop. The result is dry tons of sludge per acre.

   15,643 ppm x 0.002 = 31.3 lbs/DT

   $$\frac{250 \text{ lbs/acre}}{31.3 \text{ lbs/DT}} = 8.0 \text{ DT/A}$$

d. Determine pounds of Cadmium per dry ton of sludge and divide into 0.446 pounds of cadmium per acre. The result is dry tons of sludge per acre.

   $$\frac{0.446 \text{ lb Cd/A}}{7.755 \text{ ppm Cd} \times 0.002} = 28.8 \text{ DT/A}$$

e. The governing parameter for the annual application rate as determined above is 8.0 dry tons per acre.

As previously stated, an average of 6,300 gallons of sludge are discharged to the drying beds on a daily basis. Assuming a suspended solids concentration of 13,300 mgl, the theoretical average sludge production can be calculated to equal 10.6 dry tons per month. [(6,300 qpd) (30.4 day/month) (8.34 lbs/gal) (13,300 mgl) / (2000 lbs/TN) (10^6)]. Therefore, a minimum of 1.3 new acres will be required every month (10.6 TN/month ·/. 8.0 TN/acre = 1.3 acres/month) to effectively dispose of the nitrogen quantities in the sludge.

As shown on Figure No. 4, approximately 700 lbs of solids are discharged to the drying beds on a daily basis. After reaching a solids concentration of at least 20 percent the sludge is removed from the drying beds and applied to land from a truck mounted dry box spreader. Consequently, the minimum acreage required to satisfy the maximum hydraulic rate criteria of the regulations is 0.5 acres per month (700 lbs/day x 7 day/wk ·/. 0.20 x 8.34 lbs/gal x 25,000 gallons/acres/wk = 0.12 acres per week = 0.5 acres per month) which is approximately one-third of the land required to dispose of the nitrogen quantities. Therefore, the maximum hydraulic rate criteria is not the controlling factor for sludge disposal under the present mode of operation in Tahlequah.

C. FUTURE SLUDGE PRODUCTION

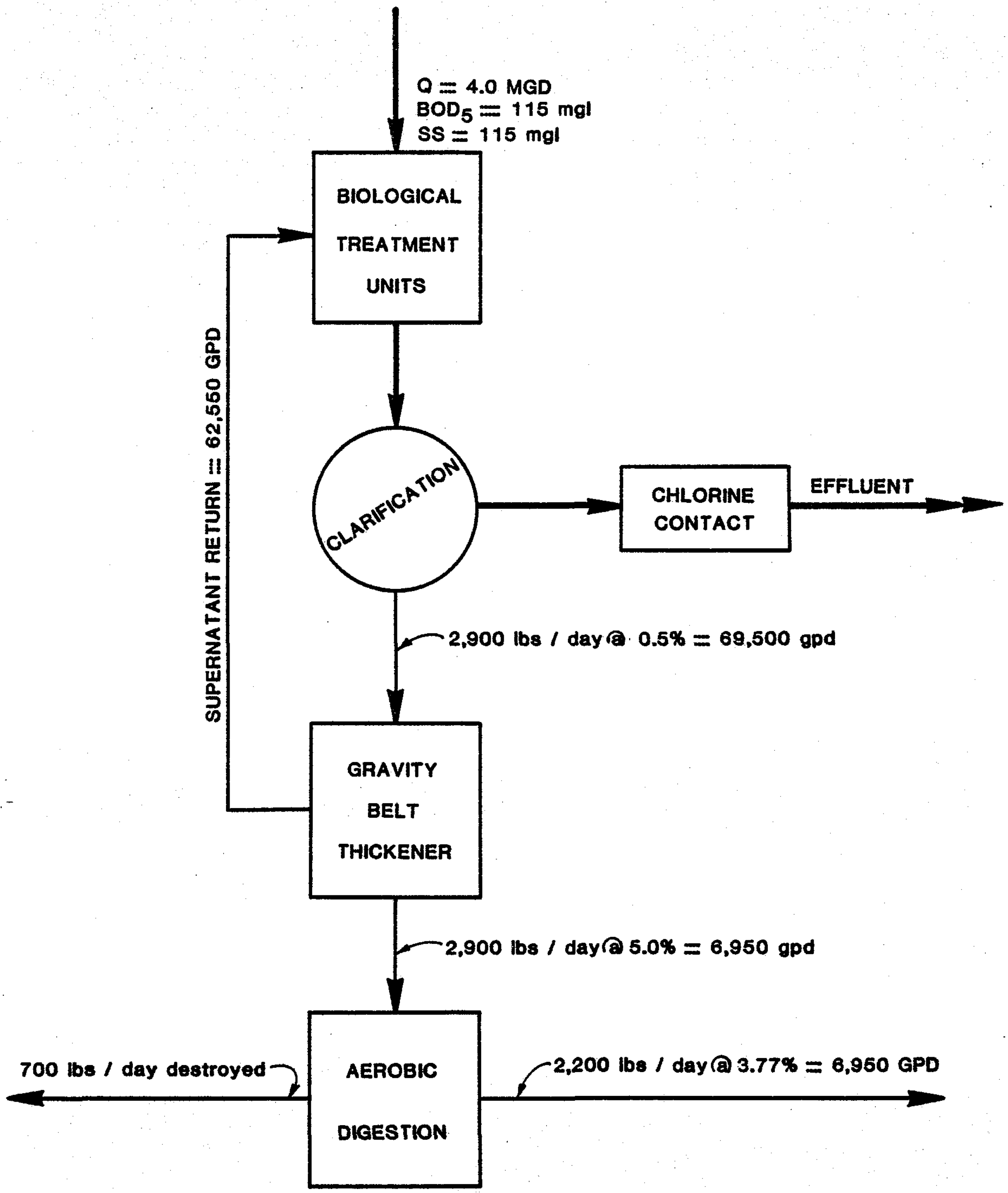
1. **Sludge Quantity.** To meet the future needs of Tahlequah, a 4.0 mgd facility capable of biologically removing nitrogen and phosphorus from wastewater having the following characteristics has been proposed.

BOD_5	115 mgl
SS	115 mgl
NH_3-N	16 mgl
P	4 mgl

As can be seen from Figure No. 5, the theoretical sludge production from the proposed plant, based on the above characteristics, is 2,900 lbs per day. The digested sludge production at the design flow is estimated to be 2,200 lbs per day. At an estimated discharge concentration of 3.77 percent solids, the volume to disposal is approximately 6,950 gpd or 2.5 million gallons per year.

Present plans call for the two existing 84 feet diameter treatment units to be converted to the aerobic digestion units. At the proposed normal sidewater depth of 10 feet, the two converted units will provide nearly twice the detention time required under aerobic conditions thus enabling the facility to generate level II sludge [2 x 3.14 x (42 feet)^2 x 7.48 gallons/cu. ft. x 10 feet ·/. 6,950 gallons per day = 119 days]. An additional 60 days storage can be obtained during periods of inclement weather by allowing the liquid level to reach a depth of 15 feet. This latter feature will give plant operating personnel the flexibility they need to operate the sludge disposal system during periods of inclement weather.

2. **Chemical Composition.** The chemical composition of the sludge produced by the proposed treatment facility will not be significantly different in terms of heavy metal content than the sludge produced by the existing treatment plant. However, because the proposed facility utilizes a treatment process that converts ammonia nitrogen to nitrates and subsequently converts the nitrates to nitrogen gas, the plant available nitrogen in the sludge will be limited to a small fraction of the influent organic N and that portion of the ammonia nitrogen assimilated into cell mass during the nitrification-denitrification process.



HTB, INC.
ARCHITECTS
ENGINEERS
PLANNERS

TAHLEQUAH PUBLIC WORKS AUTHORITY
SLUDGE MANAGEMENT PLAN

SLUDGE PRODUCTION
FUTURE CONDITIONS

FIGURE NO. 5

The treatment process proposed for the new facility removes phosphorus from wastewater through a phenomenon known as "luxury uptake". Although the actual mechanism for phosphorus removal is not fully understood, it is known that microorganisms in an activated sludge mixed liquor are, under certain ideal conditions, able to remove several times the amount of phosphorus required for growth.

Because of the large phosphorus concentrations anticipated in the sludge generated by the future facility, the OSH Cooperative Extension Service was consulted to determine what impact the application of such sludges might have on the disposal sites. As indicated by Dr. Billy Tucker's letter dated November 5, 1987 (see Appendix C), it is the residual soluble phosphorus concentration not the total phosphorus concentration that is of concern following land application of municipal wastewater treatment plant sludge.

Dr. Tucker further indicated that soluble phosphorus, when applied to soils, reverts to insoluble forms. However, since the amount that remains soluble and chemically active depends on the soil and is site specific, Dr. Tucker concluded it would be difficult to predict the fate of the added phosphorus. He, therefore, recommended that the high phosphorus concentration sludge be applied commensurate with the nitrogen needs of the crop and that the soil be annually monitored to determine phosphorus residuals.

3. <u>Determination of Application Rates.</u> If sufficient nutrients are found in the raw wastewater, the sludge produced by a biological phosphorus removal system can contain up to 6 percent by weight, of the total suspended solids as N, and up to 5 percent, by weight, phosphorus. Almost all of the nitrogen in the sludge is organic in nature with only a minute fraction being present as ammonia nitrogen or nitrates.

With the above facts in mind, the annual application rate for the future sludge production can be determined as follows:

a. Calculate PA-N value based on 6 percent organic nitrogen content of sludge.

   PA-N = 0.20 x 60,000 ppm = 12,000 ppm

b. Determine pounds of PA-N per dry ton of sludge and divide into pounds of Nitrogen required for the crop (250 lbs/acre for Bermuda grass pasture). The result is dry tons of sludge per acre.

   12,000 ppm x 0.002 = 24 lbs/DT

   $\frac{250 \text{ lbs/acre}}{24 \text{ lbs/DT}}$ = 10.4 DT/Acre

c. On the basis of solids leading criteria, therefore, the governing parameter for the annual application rate for the future facility will be based, on the 8.0 dry tons per acre requirement in the Regulations rather than on the nitrogen content of the sludge.

As noted above, the theoretical quantity of sludge to be disposed of by land application from the proposed facility is 2,200 lbs per day which equals 33.5 dry tons per month. Therefore, a minimum of 4.2 new acres will be required every month (33.5 TN/month ·/. 8.0 TN/acre = 4.2 acres/month) to effectively dispose of the solids contained in the sludge.

It was also noted previously that the total volume to be disposed of by the land application system will be 6,950 gallons per day. The minimum acreage required to satisfy the maximum hydraulic rate criteria of the regulations, therefore, is 1.95 acres/wk (6,950 gpd x 7 days/wk ·/. 25,000 gal/acre/wk = 1.95 acres/wk) or 8.5 new acres per month. Because the hydraulic application criteria requires twice the acreage required of the solids disposal criteria it will become the controlling factor for sludge disposal during the operation of the future facility.

4. <u>Aerobic Sludge Digestion Testing and Records.</u> The aerobic digestion process is a continuation of the aeration process performed in the activated sludge nitrification basins. The bacterial action begun in the aeration process continues in the presence of oxygen but the organic food available is limited. The result is the self-destruction of active bacteria, producing a stable, odorless sludge.

To determine the efficiency of the digestion process, total suspended solids and volatile suspended solids tests should be performed. The reduction in volatile suspended solids should be apparent from the comparison of the ratio of total suspended solids to volatile suspended solids before and after digestion.

An operating log will be maintained by the plant's operating personnel to provide useful information that will aid in the operation of the aerobic digestion process. The log should include as a minimum the following:

Method of Operation
- Single-Stage
- Two-Stage

Dissolved Oxygen
- Basin No. 1
- Basin No. 2

Decanting
- Frequency
- Depth